What is claimed is:

1. A method, comprising:

depositing a metal layer onto a surface of an underlayer, wherein the surface is selected to be substantially free of oxide; and

directing additional metal towards the metal layer, in the presence of oxygen, to form a magnesium-zinc oxide tunnel barrier in contact with the underlayer, the oxygen reacting with the additional metal and the metal layer, wherein:

at least one of the metal layer and the additional metal includes Zn, and

at least one of the metal layer and the additional metal includes Mg.

2. The method of Claim 1, wherein the metal layer includes Mg but substantially no Zn.

3. The method of Claim 1, wherein the metal layer includes Zn but substantially no Mg.

4. The method of Claim 1, wherein the metal layer includes both Mg and Zn.

5. The method of Claim 1, wherein the additional metal includes Mg but substantially no Zn.

6. The method of Claim 1, wherein the additional metal includes Zn but substantially no Mg.

7. The method of Claim 1, wherein the additional metal includes both Mg and Zn.

8. The method of Claim 1, wherein the metal layer includes Mg but substantially no Zn, and the additional metal includes Zn but substantially no Mg.

9. The method of Claim 1, wherein the metal layer includes Zn but substantially no Mg, and the additional metal includes Mg but substantially no Zn.

10. The method of Claim 1, wherein the tunnel barrier is a $[Zn_{1-x}Mg_x]O$ tunnel barrier, in which x represents an atomic percentage in the range of 1 to 99.

11. The method of Claim 1, wherein the tunnel barrier includes a layer of $[Zn_{1-y}Mg_y]O$ and a layer of $[Zn_{1-x}Mg_x]O$, wherein x and y represent respective atomic percentages in the ranges of 1 to 99 and 1 to 100, respectively.

12. The method of Claim 1, wherein the thickness of the metal layer is selected to be large enough to prevent oxidation of the underlayer but small enough that, upon reaction of the oxygen with the metal layer, substantially all the metal in the metal layer is oxidized.

13. The method of Claim 1, further comprising annealing the tunnel barrier to improve its performance.

14. The method of Claim 1, wherein the metal layer is deposited in the absence of substantial amounts of reactive oxygen, the metal layer being oxidized as the tunnel barrier is formed.

15. The method of Claim 1, wherein the tunnel barrier has a thickness of between 3 and 50 angstroms.

16. The method of Claim 1, wherein the metal layer has a thickness of between 3 and 50 angstroms.

17. The method of Claim 1, wherein the metal layer has a thickness of between 3 and 20 angstroms.

18. The method of Claim 1, wherein the underlayer includes a semiconductor adjacent to the tunnel barrier.

19. The method of Claim 1, wherein the underlayer includes a layer of at least one

magnetic material selected from the group consisting of ferromagnetic materials and ferrimagnetic materials.

20. The method of Claim 19, wherein the magnetic layer is adjacent to the tunnel barrier.

21. The method of Claim 20, wherein the magnetic layer is ferromagnetic, bcc and substantially (100) oriented.

22. The method of Claim 19, wherein the magnetic layer includes an alloy of Fe and Co, and the Fe content of the alloy is between 1 and 99 atomic percent.

23. The method of Claim 19, further comprising forming an overlayer on the tunnel barrier to form a magnetic tunnel junction, wherein the overlayer includes a layer of at least one magnetic material selected from the group consisting of ferromagnetic materials and ferrimagnetic materials.

24. The method of Claim 23, further comprising annealing the tunnel junction to increase its tunnel magnetoresistance.

25. The method of Claim 24, wherein the tunnel junction is annealed at a temperature selected to yield a tunnel magnetoresistance of greater than 50% at room temperature.

26. The method of Claim 24, wherein the tunnel junction is annealed at a temperature selected to yield a tunnel magnetoresistance of greater than 70% at room temperature.

27. The method of Claim 23, wherein the overlayer and the underlayer each include ferromagnetic material selected from the group consisting of i) Fe, ii) an alloy of Co and Fe, iii) an alloy of Ni and Fe, and iv) an alloy of Ni and Fe and Co.

28. The method of Claim 1, comprising forming an overlayer on the tunnel barrier, wherein one of the overlayer and the underlayer includes a non-ferromagnetic, non-

ferrimagnetic metal layer, and the other of the overlayer and the underlayer includes a layer of magnetic material selected from the group consisting of ferromagnetic materials and ferrimagnetic materials, thereby constructing a magnetic tunneling transistor that includes the non-ferromagnetic, non-ferrimagnetic metal layer, the tunnel barrier, and the magnetic layer.

29. The method of Claim 1, comprising forming an overlayer on the tunnel barrier, wherein the overlayer and the underlayer comprise respective non-ferromagnetic, non-ferrimagnetic metals.

30. A method, comprising:

providing an underlayer having a surface that is substantially free of oxide;

forming a metal layer on the surface to both protect the underlayer from oxidation and to wet the underlayer, the metal layer including at least one of Mg and Zn; and

directing oxygen and additional metal, the additional metal including at least one of Mg and Zn, onto the metal layer to form a magnesium-zinc oxide tunnel barrier that is in contact with the underlayer, wherein:

at least one of the metal layer and the additional layer includes Zn; and

at least one of the metal layer and the additional layer includes Mg.

31. The method of Claim 30, further comprising annealing the tunnel barrier to improve its performance.

32. A method, comprising:

forming a metal layer of a preselected thickness on a surface of an underlayer to protect the underlayer from oxidation, wherein the metal layer includes at least one of Mg and Zn; and

directing oxygen and additional metal that includes at least one of Mg and Zn towards the metal layer, so that the oxygen reacts with the metal layer and the additional metal to form a magnesium-zinc oxide tunnel barrier on the underlayer,

wherein the thickness of the metal layer is selected to be small enough that substantially all the metal of the metal layer reacts with oxygen to form part of the tunnel barrier, and wherein:

at least one of the metal layer and the additional metal includes Zn, and

at least one of the metal layer and the additional metal includes Mg.

33. The method of Claim 32, wherein the surface is selected to be substantially free of oxide.

34. The method of Claim 32, further comprising forming an overlayer on the tunnel barrier, wherein the overlayer and the underlayer each include at least one material selected from the group consisting of ferromagnetic materials and ferrimagnetic materials, thereby forming a magnetic tunnel junction.

35. The method of Claim 34, further comprising annealing the magnetic tunnel junction to increase its tunnel magnetoresistance.

36. A structure, comprising:

an underlayer that includes a first magnetic layer of at least one magnetic material selected from the group consisting of ferromagnetic materials and ferrimagnetic materials;

a magnesium-zinc oxide tunnel barrier in contact with the underlayer; and

an overlayer, the tunnel barrier being in contact with a surface of the overlayer, the tunnel barrier being sandwiched between the underlayer and the overlayer.

37. The structure of Claim 36, wherein:

the underlayer has a surface that is substantially free of oxide formed from the underlayer, and

the magnesium-zinc oxide tunnel barrier is in contact with said surface of the underlayer.

38. The structure of Claim 36, wherein the surface of the overlayer is substantially free of oxide formed from the overlayer.

39. The structure of Claim 36, wherein at least one of the overlayer and the underlayer includes a spacer layer that is in contact with the tunnel barrier, wherein the spacer layer does not substantially interfere with the tunneling properties of the tunnel barrier.

40. The structure of Claim 36, wherein the tunnel barrier has a thickness of between 3 and 50 angstroms.

41. The structure of Claim 36, wherein the tunnel barrier comprises:

a layer of $[Zn_{1-y}Mg_y]O$; and

a layer of $[Zn_{1-x}Mg_x]O$, wherein x and y represent respective atomic percentages in the ranges of 1 to 99 and 1 to 100, respectively.

42. The element of Claim 36, wherein the overlayer includes a second magnetic layer of at least one material selected from the group consisting of ferromagnetic materials and ferrimagnetic materials, wherein the first magnetic layer, the tunnel barrier, and the second magnetic layer form a magnetic tunnel junction.

43. The structure of Claim 42, wherein the overlayer and the underlayer include respective ferromagnetic materials that together with the tunnel barrier form a magnetic tunnel junction, and wherein:

i) the amount of any oxide separating the tunnel barrier from the ferromagnetic materials is sufficiently low, and

ii) the tunnel barrier, the underlayer, and the overlayer are sufficiently free of defects, such that the tunnel magnetoresistance of the magnetic tunnel junction is greater than 50% at room temperature.

44. The structure of Claim 43, wherein

i) the amount of any oxide separating the tunnel barrier from the ferromagnetic materials is sufficiently low, and

ii) the tunnel barrier, the underlayer, and the overlayer are sufficiently free of defects, such that the tunnel magnetoresistance of the magnetic tunnel junction is greater than 70% at room temperature.

45. The structure of Claim 42, wherein at least one of the underlayer and the overlayer includes antiferromagnetic material that is exchange biased with ferromagnetic material of said at least one layer, the antiferromagnetic material including at least one alloy selected from the group consisting of Ir-Mn and Pt-Mn, in which the alloy is substantially (100) oriented and is at least substantially fcc.

46. The structure of Claim 42, wherein the underlayer includes antiferromagnetic material over at least one layer selected from the group consisting of Ta and TaN.

47. The structure of Claim 42, wherein the tunnel barrier is in direct contact with both ferromagnetic material of the underlayer and ferromagnetic material of the overlayer.

48. The structure of Claim 42, wherein the tunnel barrier has a thickness of between 3 and 50 angstroms.

49. The structure of Claim 36, wherein the overlayer includes a metallic layer of non-ferromagnetic, non-ferrimagnetic material in contact with the tunnel barrier, wherein the metallic layer, the tunnel barrier, and the first magnetic layer form a magnetic tunneling transistor.

50. The structure of Claim 36, wherein the overlayer includes a layer of semiconductor material in contact with the tunnel barrier, wherein the semiconductor layer, the tunnel barrier, and the first magnetic layer form a spin injector device.

51. The structure of Claim 36, wherein the overlayer includes a layer of non-ferromagnetic, non-ferrimagnetic metal.

52. A structure, comprising:

an underlayer having a surface that is substantially free of oxide formed from the underlayer;

a magnesium-zinc oxide tunnel barrier in contact with the surface of the underlayer, wherein the tunnel barrier has a thickness of between 3 and 50 angstroms; and

an overlayer, the tunnel barrier being in contact with a surface of the overlayer, the tunnel barrier being sandwiched between the underlayer and the overlayer.